7.48 A 40-cm pipe abruptly expands to a 60-cm size. These pipes are horizontal, and the discharge of water from the smaller size to the larger is 1.0 m^3/s. What horizontal force is required to hold the transition in place if the pressure in the 40-cm pipe is 70 kPa gage? Also, what is the head loss?

7.48 **Information and assumptions**

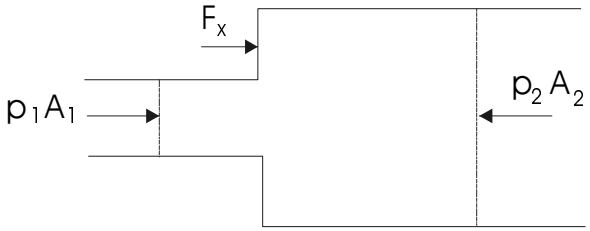
provided in problem statement

Find

horizontal force required to hold transition in place and head loss.

Solution

$$\begin{aligned}
V_{40} &= Q/A_{40} = 1.0/((\pi/4) \times 0.40^2) = 7.962 \text{ m/s} \\
V_{40}^2/2g &= 3.231 \text{ m} \\
V_{60} &= V_{40} \times (4/6)^2 = 3.539 \text{ m/s} \\
V_{60}^2/2g &= 0.638 \text{ m} \\
h_L &= (V_{40} - V_{60})^2/2g = \underline{\underline{0.997 \text{ m}}} \\
p_{40}/\gamma + V_{40}^2/2g &= p_{60}/\gamma + V_{60}^2/2g + h_L \\
p_{60} &= 70,000 + 9,810(3.231 - 0.638 - 0.997) = 85,657 \text{ Pa}
\end{aligned}$$



Momentum equation:

$$\sum F_x = \dot{m}_o V_{x,o} - \dot{m}_i V_{x,i}$$

$$\begin{aligned}
70,000 \times \pi/4 \times 0.4^2 - 85,657 \times \pi/4 \times (0.6^2) + F_x &= 1,000 \times 1.0 \times (3.539 - 7.962) \\
F_x &= -8,796 + 24,219 - 4,423 \\
&= 10,993 \text{ N} = \underline{\underline{11.0 \text{ kN}}}
\end{aligned}$$